LEVEL II SCOUR ANALYSIS FOR BRIDGE 28 (CAMBTH00460028) on TOWN HIGHWAY 46, crossing the SEYMOUR RIVER, CAMBRIDGE, VERMONT

U.S. Geological Survey
Open-File Report 97-648

Prepared in cooperation with
VERMONT AGENCY OF TRANSPORTATION
and
FEDERAL HIGHWAY ADMINISTRATION

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By MICHAEL A. IVANOFF

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Slope	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Velocity and Flow	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	MC	main channel
D_{50}	median diameter of bed material	RAB	right abutment
DS	downstream	RABUT	face of right abutment
elev.	elevation	RB	right bank
f/p	flood plain	ROB	right overbank
ft^2	square feet	RWW	right wingwall
ft/ft	feet per foot	TH	town highway
JCT	junction	UB	under bridge
LAB	left abutment	US	upstream
LABUT	face of left abutment	USGS	United States Geological Survey
LB	left bank	VTAOT	Vermont Agency of Transportation
LOB	left overbank	WSPRO	water-surface profile model

In this report, the words “right” and “left” refer to directions that would be reported by an observer facing downstream.

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929-- a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

In the appendices, the above abbreviations may be combined. For example, USLB would represent upstream left bank.

LEVEL II SCOUR ANALYSIS FOR BRIDGE 28 (CAMBTH00460028) ON TOWN HIGHWAY 46, CROSSING THE SEYMOUR RIVER, CAMBRIDGE, VERMONT

By **Michael A. Ivanoff**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure CAMBTH00460028 on Town Highway 46 crossing the Seymour River, Cambridge, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province in northwestern Vermont. The 9.94-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture while the immediate banks have dense woody vegetation.

In the study area, the Seymour River has an incised, straight channel with a slope of approximately 0.02 ft/ft, an average channel top width of 81 ft and an average bank height of 5 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 62.0 mm (0.204 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 11, 1995, indicated that the reach was stable.

The Town Highway 46 crossing of the Seymour River is a 38-ft-long, one-lane bridge consisting of one 33-foot steel-beam span (Vermont Agency of Transportation, written communication, March 8, 1995). The opening length of the structure parallel to the bridge face is 30.6 ft.The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 5 degrees to the opening while the measured opening-skew-to-roadway is 10 degrees.

A scour hole 0.2 ft deeper than the mean thalweg depth was observed along the upstream right wingwall and right abutment during the Level I assessment. The only scour protection measure at the site was type-1 stone fill (less than 12 inches diameter) along the upstream left road embankment. Additional details describing conditions at the site are included in the Level II Summary and Appendices D
and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge is determined and analyzed as another potential worst-case scour scenario. Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 0.0 to 0.8 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge. Left abutment scour ranged from 4.2 to 4.9 ft. The worst-case left abutment scour occurred at the 500-year discharge. Right abutment scour ranged from 8.8 to 9.7 ft. The worst-case right abutment scour occurred at the incipient roadway-overtopping discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and others, 1995, p. 47). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Mount Mansfield, VT. Quadrangle, 1:24,000, 1948
Photorevised, 1980

NORTH

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

LEVEL II SUMMARY

Structure Number CAMBTH00460028 ***Stream*** Seymour River

County Lamoille ***Road*** TH 46 ***District*** 8

Description of Bridge

Bridge length 38 ***ft*** ***Bridge width*** 14.3 ***ft*** ***Max span length*** 33 ***ft***

Alignment of bridge to road (on curve or straight) Straight

Abutment type Vertical, concrete ***Embankment type*** Vertical, left; sloping, right

Stone fill on abutment? No ***Date of inspection*** 7/11/95

Description of stone fill Type-1, along the upstream left road embankment.

Abutments and wingwalls are concrete. There is a 0.2 ft deep scour hole and 0.2 ft deep undermining in front of the upstream right wingwall and abutment.

Yes

Is bridge skewed to flood flow according to survey? 5 ***Angle*** No

7/11/95

Debris accumulation on bridge at time of Level I or Level II site visit:

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	7/11/95	0	0
Level II		0	0

Potential for debris Moderate. There is some downed trees and trees leaning over the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date) None 7/11/95.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with wide flood plain and steep valley walls on both sides.

Geomorphic conditions at bridge site: downstream (DS), upstream (US)

Date of inspection 7/11/95

DS left: Steep channel bank to the flood plain.

DS right: Steep channel bank to the moderately sloped overbank.

US left: Steep channel bank to the flood plain.

US right: Steep channel bank to the moderately sloped overbank.

Description of the Channel

Average top width 81 ***ft*** ***Average depth*** 5 ***ft***

Predominant bed material Gravel / Cobbles ***Bank material*** Sand /Cobbles

Straight with non-alluvial channel boundaries and a wide flood plain.

7/11/95

Vegetative co[illegible] Trees and brush with pasture on the floodplain.

DS left: Trees and brush with pasture on the overbank.

DS right: Trees and brush with pasture on the flood plain.

US left: Trees and brush with pasture on the overbank.

US right:

Do banks appear stable? Y ***If not, describe location and type of instability and date of observation.***

There were some fallen trees in the upstream channel as of 7/11/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 9.94 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	*Percent of drainage area*
New England/Green Mountain	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: There are a couple of barns and a house on the right overbank area.

Is there a USGS gage on the stream of interest? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 2,870 ***ft³/s*** ***Q500*** 4,075 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(9.94/12.3)exp 0.7] with the discharges above the confluence of Settlement Brook in Cambridge. Settlement Brook enters the Seymour River downstream of this site and has flood frequency estimates available from the Flood Insurance Study for Cambridge, VT (Federal Emergency Management Agency, 1982). The drainage area above the confluence of Settlement Brook is 12.3 square miles. The drainage area adjusted discharge values are within a range defined by several empirical flood frequency curves (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

Description of the Water-Surface Profile Model (WSPRO) Analysis

Datum for WSPRO analysis (USGS survey, sea level, VTAOT plans) USGS survey

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the left abutment (elev. 499.68 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the right abutment (elev. 498.58 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	*Section Reference Distance (SRD) in feet*	*[2]Cross-section development*	*Comments*
EXITX	-42	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPRO	47	2	Modelled Approach section (Templated from APTEM)
APTEM	55	1	Approach section as surveyed (Used as a template)

[1] For location of cross-sections see plan-view sketch included with Level I field form, Appendix E.
For more detail on how cross-sections were developed see WSPRO input file.

Data and Assumptions Used in WSPRO Model

Hydraulic analyses of the reach were done by use of the Federal Highway Administration's WSPRO step-backwater computer program (Shearman and others, 1986, and Shearman, 1990). The analyses reported herein reflect conditions existing at the site at the time of the study. Furthermore, in the development of the model it was necessary to assume no accumulation of debris or ice at the site. Results of the hydraulic model are presented in the Bridge Hydraulic Summary, Appendix B, and figure 7.

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.048 to 0.058, and overbank "n" values were 0.035.

Critical depth was used as the starting water surface elevation at the exit section (EXITX) for the 100-year and 500-year discharges. Normal depth was computed no more than 0.5 foot below critical depth. For the incipient roadway-overtopping model normal depth at the exit section (EXITX) was assumed as the starting water surface. Starting water surface elevations were computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.018 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1948).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.020 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.4 ***ft***
Average low steel elevation 499.4 ***ft***

100-year discharge 2,870 ***ft^3/s***
Water-surface elevation in bridge opening 498.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,338 ***ft^3/s***
Area of flow in bridge opening 216 ***ft^2***
Average velocity in bridge opening 7.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 8.8 ***ft/s***

Water-surface elevation at Approach section with bridge 499.1
Water-surface elevation at Approach section without bridge 498.3
Amount of backwater caused by bridge 0.8 ***ft***

500-year discharge 4,075 ***ft^3/s***
Water-surface elevation in bridge opening 498.6 ***ft***
Road overtopping? Yes ***Discharge over road*** 2,430 ***ft^3/s***
Area of flow in bridge opening 233 ***ft^2***
Average velocity in bridge opening 7.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 8.8 ***/s***

Water-surface elevation at Approach section with bridge 499.6
Water-surface elevation at Approach section without bridge 498.6
Amount of backwater caused by bridge 1.0 ***ft***

Incipient overtopping discharge 1,330 ***ft^3/s***
Water-surface elevation in bridge opening 494.8 ***ft***
Area of flow in bridge opening 119 ***ft^2***
Average velocity in bridge opening 11.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.6 ***ft/s***

Water-surface elevation at Approach section with bridge 497.5
Water-surface elevation at Approach section without bridge 496.3
Amount of backwater caused by bridge 1.2 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour for all discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The computed streambed armoring depths suggest that armoring will not limit the depth of contraction scour.

Abutment scour was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	0.8
Depth to armoring	0.4	0.4	27.8
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	4.2	4.9	4.8
Right abutment	9.6	8.8	9.7
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	0.9	1.0	1.7
Right abutment	0.9	1.0	1.7
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

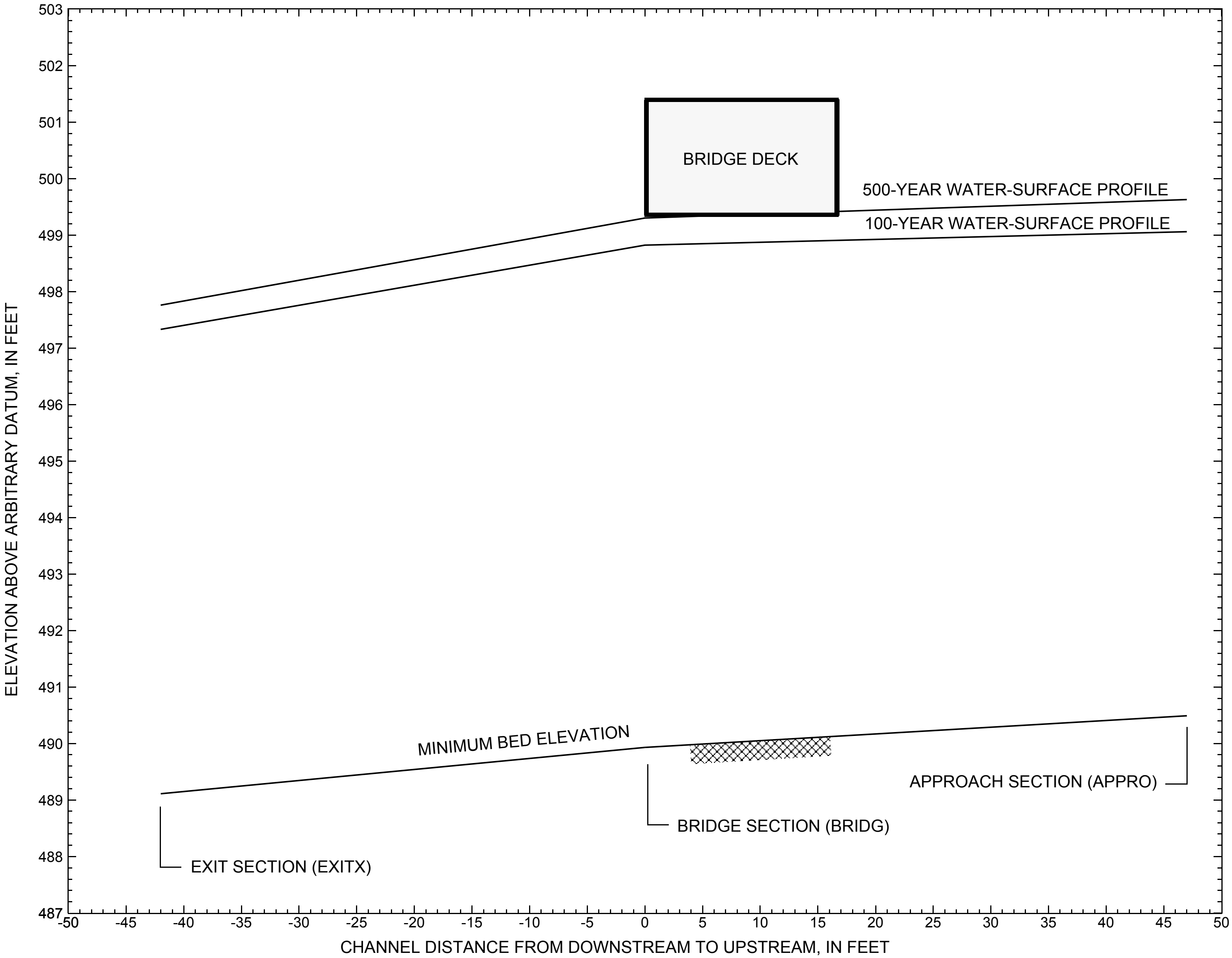

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure CAMBTH00460028 on Town Highway 46, crossing the Seymour River, Cambridge, Vermont.

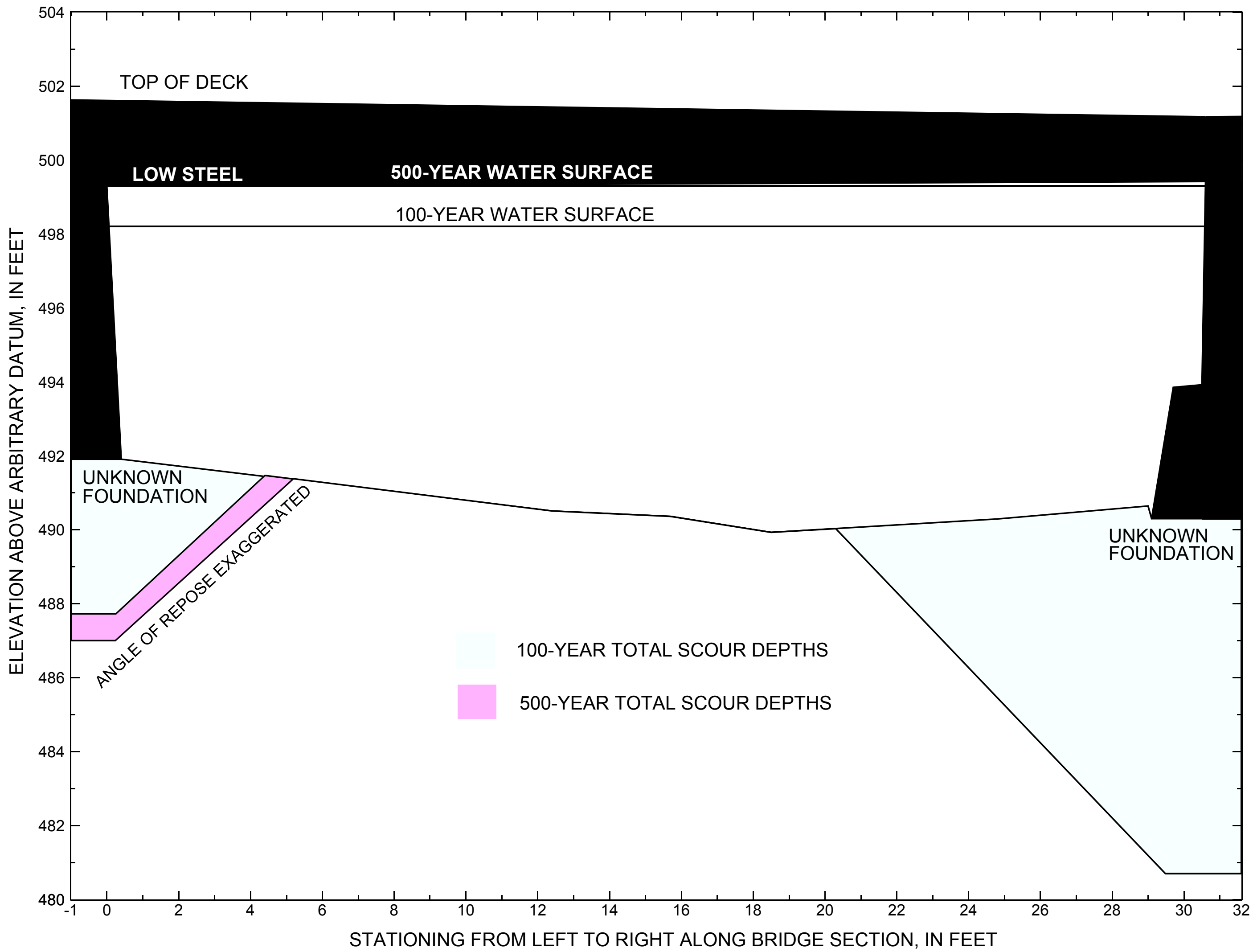

Figure 8. Scour elevations for the 100-year and 500-year discharges at structure CAMBTH00460028 on Town Highway 46, crossing the Seymour River, Cambridge, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure CAMBTH00460028 on Town Highway 46, crossing the Seymour River, Cambridge, Vermont.

[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-year. discharge is 2,870 cubic-feet per second											
Left abutment	0.0	--	499.3	--	491.9	0.0	4.2	--	4.2	487.7	--
Right abutment	30.6	--	499.4	--	490.3	0.0	9.6	--	9.6	480.7	--

1.Measured along the face of the most constricting side of the bridge.

2.Arbitrary datum for this study.

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure CAMBTH00460028 on Town Highway 46, crossing the Seymour River, Cambridge, Vermont.

[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year. discharge is 4,075 cubic-feet per second											
Left abutment	0.0	--	499.3	--	491.9	0.0	4.9	--	4.9	487.0	--
Right abutment	30.6	--	499.4	--	490.3	0.0	8.8	--	8.8	481.5	--

1.Measured along the face of the most constricting side of the bridge.

2.Arbitrary datum for this study.

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U.S. Geological Survey, 1948, Mount Mansfield, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photorevised 1980, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File camb028.wsp
T2        Hydraulic analysis for structure CAMBTH00460028   Date: 15-APR-97
T3        TH 46 crossing the Seymour River, 0.1 miles to junction of TH 1
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2870.0   4075.0   1330.0
SK          0.0180   0.0180   0.0180
WS          497.33   497.76   495.42
*
XS   EXITX    -42
GR         -486.7, 501.19   -396.5, 497.57   -298.1, 497.22   -210.8, 496.47
GR         -126.5, 496.38    -24.9, 496.38     -4.1, 497.11
GR            0.0, 496.35      5.1, 491.02     12.2, 489.90     20.1, 489.11
GR           26.1, 489.31     29.3, 489.85     34.8, 490.44     40.2, 495.31
GR           43.3, 496.45     92.6, 496.42    185.1, 497.89    192.4, 498.29
GR          392.4, 501.42
N           0.035     0.058      0.035
SA                -4.1      43.3
*
*
XS   FULLV      0 * * *   0.0066
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    499.36      10.0
GR            0.0, 499.29      0.4, 491.91      7.0, 491.18     12.4, 490.51
GR           15.7, 490.36     18.5, 489.93     24.8, 490.29     29.0, 490.64
GR           29.1, 490.30     29.7, 493.85     30.5, 493.92     30.6, 499.42
GR            0.0, 499.29
*
*         BRTYPE BRWDTH       WWANGL    WWWID
CD           1      27.2 * *     67.6      6.1
N           0.048
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      8      14.3     2
GR         -599.1, 504.20   -430.1, 499.26   -282.5, 497.79   -168.3, 497.43
GR         -113.9, 497.42    -75.5, 498.20    -34.8, 500.05    -15.2, 501.43
GR            0.0, 501.62     37.2, 501.17     54.6, 501.20     81.1, 500.06
GR          153.3, 499.56    223.3, 499.84    400.1, 501.88    494.4, 502.74
*
*
XT   APTEM     55
GR         -539.1, 501.45   -452.5, 497.66   -388.1, 497.40
GR         -105.0, 497.66    -63.9, 497.87    -14.7, 496.13      0.0, 493.45
GR           14.4, 492.45     22.8, 491.40     25.6, 491.05     31.3, 490.65
GR           34.7, 491.27     37.0, 491.51     40.7, 491.27     45.5, 491.46
GR           50.4, 496.27     71.1, 496.82    100.9, 497.23    134.8, 498.98
GR          334.8, 501.12
*   At the incipient roadway-overtopping discharge the approach section was
*   ended at -63.9 to prevent excessive flow along the left overbank.
AS   APPRO     47 * * * 0.020
GT
N           0.035     0.058     0.035
SA               -63.9      50.4
*
HP 1 BRIDG   498.05 1 498.05
HP 2 BRIDG   498.05 * * 1532
HP 2 RDWAY   498.82 * * 1338
HP 1 APPRO   499.06 1 499.06
HP 2 APPRO   499.06 * * 2870
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
      U.S. Geological Survey WSPRO Input File camb028.wsp
      Hydraulic analysis for structure CAMBTH00460028   Date: 15-APR-97
      TH 46 crossing the Seymour River, 0.1 miles to junction of TH 1
         *** RUN DATE & TIME: 07-21-97 12:19

  CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRIDG; SRD =       0.

   WSEL SA#     AREA        K   TOPW   WETP ALPH    LEW    REW     QCR
          1     216.   19601.    30.    43.                       3291.
 498.04         216.   19601.    30.    43. 1.00     0.    31.   3291.


  VELOCITY DISTRIBUTION: ISEQ = 3; SECID = BRIDG; SRD =       0.

       WSEL     LEW     REW    AREA        K        Q    VEL
     498.05     0.1    30.6   216.5   19640.    1532.   7.08

X STA.        0.1        3.4        5.3        7.0        8.4        9.8
  A(I)           19.7       12.3       11.1       10.1        9.6
  V(I)           3.89       6.21       6.93       7.62       7.94

X STA.        9.8       11.1       12.4       13.6       14.7       15.9
  A(I)            9.4        9.1        8.9        8.9        8.9
  V(I)           8.12       8.44       8.60       8.64       8.58

X STA.       15.9       17.0       18.2       19.3       20.4       21.5
  A(I)            8.7        8.8        8.8        9.0        9.0
  V(I)           8.85       8.66       8.74       8.48       8.52

X STA.       21.5       22.8       24.1       25.5       27.1       30.6
  A(I)            9.6        9.8       10.8       12.5       21.4
  V(I)           7.97       7.80       7.07       6.12       3.57


  VELOCITY DISTRIBUTION: ISEQ = 4; SECID = RDWAY; SRD =       8.

       WSEL     LEW     REW    AREA        K        Q    VEL
     498.82 -385.9   -61.9   310.3  12836.    1338.   4.31

X STA.     -385.9     -308.3     -284.9     -268.2     -253.3     -239.6
  A(I)           30.0       20.9       17.5       16.4       15.6
  V(I)           2.23       3.21       3.83       4.08       4.28

X STA.     -239.6     -226.8     -214.9     -203.8     -193.3     -183.2
  A(I)           15.1       14.6       14.0       13.5       13.4
  V(I)           4.42       4.58       4.77       4.96       4.99

X STA.     -183.2     -173.5     -164.5     -155.3     -146.0     -136.9
  A(I)           13.1       12.6       12.8       13.0       12.6
  V(I)           5.09       5.31       5.25       5.16       5.31

X STA.     -136.9     -127.9     -118.5     -108.6      -96.0      -61.9
  A(I)           12.7       13.1       13.6       14.7       21.2
  V(I)           5.27       5.12       4.92       4.56       3.16

  CROSS-SECTION PROPERTIES: ISEQ = 5; SECID = APPRO; SRD =      47.

   WSEL SA#     AREA        K   TOPW   WETP ALPH    LEW    REW     QCR
          1     675.   39150.   424.   424.                       4830.
          2     535.   37918.   114.   117.                       6568.
          3     161.    9032.   107.   107.                       1124.
 499.06        1371.   86100.   645.   648. 1.03 -488.   157. 11161.

  VELOCITY DISTRIBUTION: ISEQ = 5; SECID = APPRO; SRD =      47.

       WSEL     LEW     REW    AREA        K        Q    VEL
     499.06  -488.1   157.2  1371.2   86100.    2870.   2.09

X STA.     -488.1     -415.0     -375.2     -336.5     -295.4     -255.0
  A(I)           89.2       70.8       69.4       72.0       69.4
  V(I)           1.61       2.03       2.07       1.99       2.07

X STA.     -255.0     -212.5     -167.8     -121.5      -70.0       -7.9
  A(I)           71.3       73.3       73.8       77.3      142.9
  V(I)           2.01       1.96       1.95       1.86       1.00

X STA.       -7.9        4.0       12.7       19.8       25.9       31.1
  A(I)           63.5       55.1       50.1       47.5       43.3
  V(I)           2.26       2.60       2.86       3.02       3.31

X STA.       31.1       36.6       42.3       52.2       76.6      157.2
  A(I)           45.3       44.6       56.3       63.2       92.9
  V(I)           3.17       3.21       2.55       2.27       1.54
```

WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File camb028.wsp
        Hydraulic analysis for structure CAMBTH00460028   Date: 15-APR-97
        TH 46 crossing the Seymour River, 0.1 miles to junction of TH 1
           *** RUN DATE & TIME: 07-21-97 12:19
    CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRIDG; SRD =       0.

     WSEL SA#     AREA        K   TOPW   WETP ALPH    LEW    REW     QCR
             1     232.   21673.    30.    44.                      3652.
   498.56          232.   21673.    30.    44. 1.00     0.    31.   3652.


    VELOCITY DISTRIBUTION: ISEQ = 3; SECID = BRIDG; SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.61     0.0    30.6   233.3   21875.    1645.   7.05

X STA.         0.0        3.4        5.3        6.9        8.4        9.8
  A(I)             21.7       13.3       11.6       10.8       10.6
  V(I)             3.79       6.18       7.10       7.60       7.77

X STA.         9.8       11.1       12.3       13.5       14.7       15.8
  A(I)              9.9        9.9        9.5        9.6        9.4
  V(I)             8.32       8.33       8.67       8.58       8.80

X STA.        15.8       17.0       18.1       19.2       20.3       21.5
  A(I)              9.5        9.4        9.4        9.5        9.9
  V(I)             8.69       8.79       8.73       8.64       8.34

X STA.        21.5       22.8       24.0       25.5       27.1       30.6
  A(I)             10.4       10.6       11.7       13.5       23.4
  V(I)             7.95       7.78       7.04       6.08       3.52

    VELOCITY DISTRIBUTION: ISEQ = 4; SECID = RDWAY; SRD =       8.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.30 -431.5   -51.3   479.9   23864.    2430.   5.06

X STA.      -431.5     -335.6     -307.3     -286.9     -270.0     -254.6
  A(I)             48.3       31.7       27.9       25.6       24.3
  V(I)             2.52       3.83       4.35       4.74       5.00

X STA.      -254.6     -240.6     -227.0     -214.3     -202.4     -190.9
  A(I)             22.6       22.6       21.7       20.7       20.5
  V(I)             5.39       5.37       5.61       5.86       5.92

X STA.      -190.9     -179.9     -169.2     -158.6     -148.3     -137.9
  A(I)             20.0       19.8       19.8       19.3       19.4
  V(I)             6.07       6.15       6.13       6.28       6.26

X STA.      -137.9     -127.5     -116.8     -105.5      -90.6      -51.3
  A(I)             19.5       20.1       20.6       23.2       32.2
  V(I)             6.23       6.04       5.90       5.24       3.78

    CROSS-SECTION PROPERTIES: ISEQ = 5; SECID = APPRO; SRD =      47.

     WSEL SA#     AREA        K   TOPW   WETP ALPH    LEW    REW     QCR
             1     920.   64352.   437.   437.                      7578.
             2     600.   45922.   114.   117.                      7804.
             3     237.   13134.   160.   160.                      1640.
   499.63         1758. 123408.   712.   714. 1.03  -501.   211.  15482.


    VELOCITY DISTRIBUTION: ISEQ = 5; SECID = APPRO; SRD =      47.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.63 -501.2   210.5 1757.9  123408.    4075.   2.32

X STA.      -501.2     -424.6     -387.4     -351.8     -316.3     -280.0
  A(I)            112.8       86.3       84.3       83.2       83.7
  V(I)             1.81       2.36       2.42       2.45       2.43

X STA.      -280.0     -242.5     -204.2     -165.7     -126.2      -84.2
  A(I)             85.2       85.9       84.7       85.6       88.7
  V(I)             2.39       2.37       2.41       2.38       2.30

X STA.       -84.2      -22.7        0.4       11.2       20.2       27.4
  A(I)            149.0      104.3       72.9       67.6       61.1
  V(I)             1.37       1.95       2.80       3.02       3.33

X STA.        27.4       33.9       41.3       53.1       81.6      210.5
  A(I)             58.9       62.0       73.8       88.2      139.8
  V(I)             3.46       3.29       2.76       2.31       1.46
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      U.S. Geological Survey WSPRO Input File camb028.wsp
      Hydraulic analysis for structure CAMBTH00460028   Date: 15-APR-97
      TH 46 crossing the Seymour River, 0.1 miles to junction of TH 1
         *** RUN DATE & TIME: 07-21-97 10:22

  CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRIDG; SRD =       0.

   WSEL SA#     AREA        K   TOPW   WETP ALPH    LEW    REW     QCR
          1     119.    8068.    30.    37.                      1348.
 494.79         119.    8068.    30.    37. 1.00     0.    31.   1348.


  VELOCITY DISTRIBUTION: ISEQ = 3; SECID = BRIDG; SRD =       0.

       WSEL     LEW     REW    AREA        K        Q    VEL
     494.79     0.2    30.5   118.9    8068.    1330. 11.18

X STA.        0.2        3.5        5.6        7.4        9.0       10.4
  A(I)            9.7        6.8        6.1        5.9        5.5
  V(I)           6.87       9.73      10.90      11.19      12.13

X STA.       10.4       11.7       13.0       14.2       15.4       16.5
  A(I)            5.4        5.3        5.2        5.1        5.0
  V(I)          12.26      12.47      12.91      13.15      13.32

X STA.       16.5       17.6       18.6       19.7       20.7       21.9
  A(I)            5.0        4.9        5.0        5.0        5.1
  V(I)          13.20      13.58      13.41      13.37      12.97

X STA.       21.9       23.0       24.2       25.5       27.1       30.5
  A(I)            5.2        5.6        5.8        6.6       10.8
  V(I)          12.76      11.94      11.52      10.11       6.16

  CROSS-SECTION PROPERTIES: ISEQ = 5; SECID = APPRO; SRD =      47.

   WSEL SA#     AREA        K   TOPW   WETP ALPH    LEW    REW     QCR
          2     362.   20307.   109.   112.                      3730.
          3      46.    1657.    60.    60.                       231.
 497.54         408.   21964.   169.   172. 1.04   -59.   110.   3527.


  VELOCITY DISTRIBUTION: ISEQ = 5; SECID = APPRO; SRD =      47.

       WSEL     LEW     REW    AREA        K        Q    VEL
     497.54   -59.1   110.0   407.9   21964.    1330.   3.26

X STA.      -59.1       -7.2        1.3        6.9       11.6       15.5
  A(I)           51.9       31.4       25.5       22.7       20.5
  V(I)           1.28       2.12       2.61       2.92       3.25

X STA.       15.5       18.9       21.9       24.4       26.8       29.0
  A(I)           18.8       18.0       16.2       15.5       15.0
  V(I)           3.53       3.70       4.11       4.28       4.44

X STA.       29.0       31.0       33.0       35.2       37.4       39.6
  A(I)           14.2       14.1       14.0       14.1       13.6
  V(I)           4.68       4.71       4.76       4.72       4.90

X STA.       39.6       41.7       44.0       46.7       60.0      110.0
  A(I)           13.7       14.1       16.2       24.7       33.7
  V(I)           4.84       4.71       4.10       2.69       1.97
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```
        U.S. Geological Survey WSPRO Input File camb028.wsp
        Hydraulic analysis for structure CAMBTH00460028   Date: 15-APR-97
        TH 46 crossing the Seymour River, 0.1 miles to junction of TH 1
           *** RUN DATE & TIME: 07-21-97 12:19

===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX": USED WSI = CRWS.
                             WSI,CRWS =   496.85     497.33

XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K ALPH    HO     ERR     FR#     VEL

EXITX:XS   ****** -329.     573.  0.59 *****  497.92  497.33   2870.  497.33
      -42. ******   150.   31215.  1.50 ***** *******    0.99    5.01

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.80     497.83     497.61

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   496.83     501.70    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   496.83     501.70     497.61

FULLV:FV      42.  -380.     664.  0.43  0.31  498.22  497.61   2870.  497.79
        0.    42.   161.   36053.  1.49  0.00   -0.01    0.84    4.32
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      47.  -470.     881.  0.19  0.24  498.45 *******   2870.  498.26
       47.    47.   124.   45560.  1.15  0.00    0.00    0.50    3.26
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===230 REJECTED FLOW CLASS 1 SOLUTION.
              WS1,WSSD,WS3 =   501.29       0.00     497.42
                      CRWS =   497.73   ********     497.42
                      YMAX =   501.29   ********     499.42

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

BRIDG:BR      42.     0.     217.  0.78  0.33  498.83  495.14   1532.  498.05
        0.    42.    31.   19647.  1.00  0.58    0.00    0.46    7.08

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    4.  1.000 ******  499.36 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    33.  0.04  0.07  499.10    0.00   1338.  498.82

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1338.   324.  -386.   -62.   1.4   1.0   5.0   4.3   1.2   3.0
   RT:       0. ****** ****** ****** ***** ***** ***** ***** ***** *****

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

APPRO:AS      20.  -488.    1371.  0.07  0.13  499.13  497.73   2870.  499.06
       47.    47.   157.   86100.  1.03  0.17    0.00    0.26    2.09

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.949  0.757   21013.     2.    32. ********

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -42.  -329.   150.   2870.   31215.     573.    5.01  497.33
   FULLV:FV       0.  -380.   161.   2870.   36053.     664.    4.32  497.79
   BRIDG:BR       0.     0.    31.   1532.   19647.     217.    7.08  498.05
   RDWAY:RG       8.*******  1338.   1338.*********       0.    2.00  498.82
   APPRO:AS      47.  -488.   157.   2870.   86100.    1371.    2.09  499.06

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       2.    32.   21013.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS     497.33    0.99  489.11  501.42************  0.59  497.92  497.33
   FULLV:FV     497.61    0.84  489.39  501.70  0.31  0.00  0.43  498.22  497.79
   BRIDG:BR     495.14    0.46  489.93  499.42  0.33  0.58  0.78  498.83  498.05
   RDWAY:RG  ****************  497.42  504.20  0.04******  0.07  499.10  498.82
   APPRO:AS     497.73    0.26  490.49  501.29  0.13  0.17  0.07  499.13  499.06
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       U.S. Geological Survey WSPRO Input File camb028.wsp
       Hydraulic analysis for structure CAMBTH00460028   Date: 15-APR-97
       TH 46 crossing the Seymour River, 0.1 miles to junction of TH 1
          *** RUN DATE & TIME: 07-21-97  12:19

 ===015 WSI IN WRONG FLOW REGIME AT SECID “EXITX”:  USED WSI = CRWS.
                          WSI,CRWS =   497.30     497.76

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******  -401.     803.  0.55 *****  498.31  497.76   4075.  497.76
      -42. ******   177.   45010.  1.38 ***** *******    0.89    5.08

FULLV:FV      42.  -405.     888.  0.43  0.30  498.61 *******   4075.  498.18
        0.    42.   185.   51277.  1.31  0.00    0.00    0.75    4.59
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      47.  -478.    1092.  0.23  0.25  498.84 *******   4075.  498.61
       47.    47.   131.   61978.  1.07  0.00   -0.01    0.51    3.73
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===230 REJECTED FLOW CLASS 1 SOLUTION.
              WS1,WSSD,WS3 =   501.29       0.00     499.15
                      CRWS =   498.05   ********     499.15
                      YMAX =   501.29   ********     499.42

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   498.61     499.45     499.63     499.36

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                        YU/Z,WSIU,WS = 1.04     499.74     499.87

 ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.

           <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

BRIDG:BR      42.     0.     233.  0.77  0.39  499.38  495.36   1645.  498.61
        0.    42.    31.   21879.  1.00  0.69    0.00    0.45    7.05

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  1.000 ******  499.36 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    33.  0.04  0.09  499.68    0.00   2430.  499.30

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   2430.   380.  -432.   -51.   1.9   1.3   5.8   5.1   1.6   3.0
   RT:      0.     6.   151.   157.   0.0   0.0   2.6 108.3   0.4   2.7

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

APPRO:AS      20.  -501.    1756.  0.09  0.17  499.71  498.05   4075.  499.63
       47.    52.   210.  123183.  1.03  0.15    0.00    0.26    2.32

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.950  0.841   19567.    -7.    24. ********

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -42.  -401.   177.   4075.   45010.     803.    5.08  497.76
   FULLV:FV       0.  -405.   185.   4075.   51277.     888.    4.59  498.18
   BRIDG:BR       0.     0.    31.   1645.   21879.     233.    7.05  498.61
   RDWAY:RG       8.******* 2430.   2430.*********       0.    2.00  499.30
   APPRO:AS      47.  -501.   210.   4075.  123183.    1756.    2.32  499.63

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -7.    24.   19567.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     497.76    0.89  489.11  501.42************  0.55  498.31  497.76
   FULLV:FV   ********    0.75  489.39  501.70  0.30  0.00  0.43  498.61  498.18
   BRIDG:BR     495.36    0.45  489.93  499.42  0.39  0.69  0.77  499.38  498.61
   RDWAY:RG  ****************  497.42  504.20  0.04******  0.09  499.68  499.30
   APPRO:AS     498.05    0.26  490.49  501.29  0.17  0.15  0.09  499.71  499.63
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File camb028.wsp
        Hydraulic analysis for structure CAMBTH00460028   Date: 15-APR-97
        TH 46 crossing the Seymour River, 0.1 miles to junction of TH 1
           *** RUN DATE & TIME: 07-21-97  10:22

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******     2.     157.  1.11 *****  495.69  493.70   1330.  494.58
      -42. ******    39.    9907.  1.00 ***** *******    0.73    8.45

FULLV:FV      42.     1.     180.  0.85  0.62  496.30 *******   1330.  495.45
        0.    42.    40.   12082.  1.00  0.00   -0.01    0.60    7.38
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      47.   -25.     251.  0.44  0.49  496.77 *******   1330.  496.33
       47.    47.    59.   14005.  1.01  0.00   -0.02    0.54    5.30
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   497.54       0.00     494.79     497.42

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

BRIDG:BR      42.     0.     119.  1.95  0.93  496.73  494.75   1330.  494.79
        0.    42.    31.    8057.  1.00  0.12    0.00    0.99   11.19

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  1.000 ******  499.36 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

APPRO:AS      20.   -59.     408.  0.17  0.24  497.71  494.68   1330.  497.54
       47.    24.   110.   21974.  1.04  0.74    0.01    0.38    3.26

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.638  0.253   16333.    12.    42. ********

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -42.     2.    39.   1330.    9907.     157.    8.45  494.58
   FULLV:FV       0.     1.    40.   1330.   12082.     180.    7.38  495.45
   BRIDG:BR       0.     0.    31.   1330.    8057.     119.   11.19  494.79
   RDWAY:RG       8.**************      0.       0.       0.    2.00********
   APPRO:AS      47.   -59.   110.   1330.   21974.     408.    3.26  497.54

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      12.    42.   16333.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    493.70    0.73  489.11  501.42************  1.11  495.69  494.58
   FULLV:FV   ********   0.60  489.39  501.70  0.62  0.00  0.85  496.30  495.45
   BRIDG:BR    494.75    0.99  489.93  499.42  0.93  0.12  1.95  496.73  494.79
   RDWAY:RG   ***************  497.42  504.20  0.12******  0.17  497.59********
   APPRO:AS    494.68    0.38  490.49  501.29  0.24  0.74  0.17  497.71  497.54
```
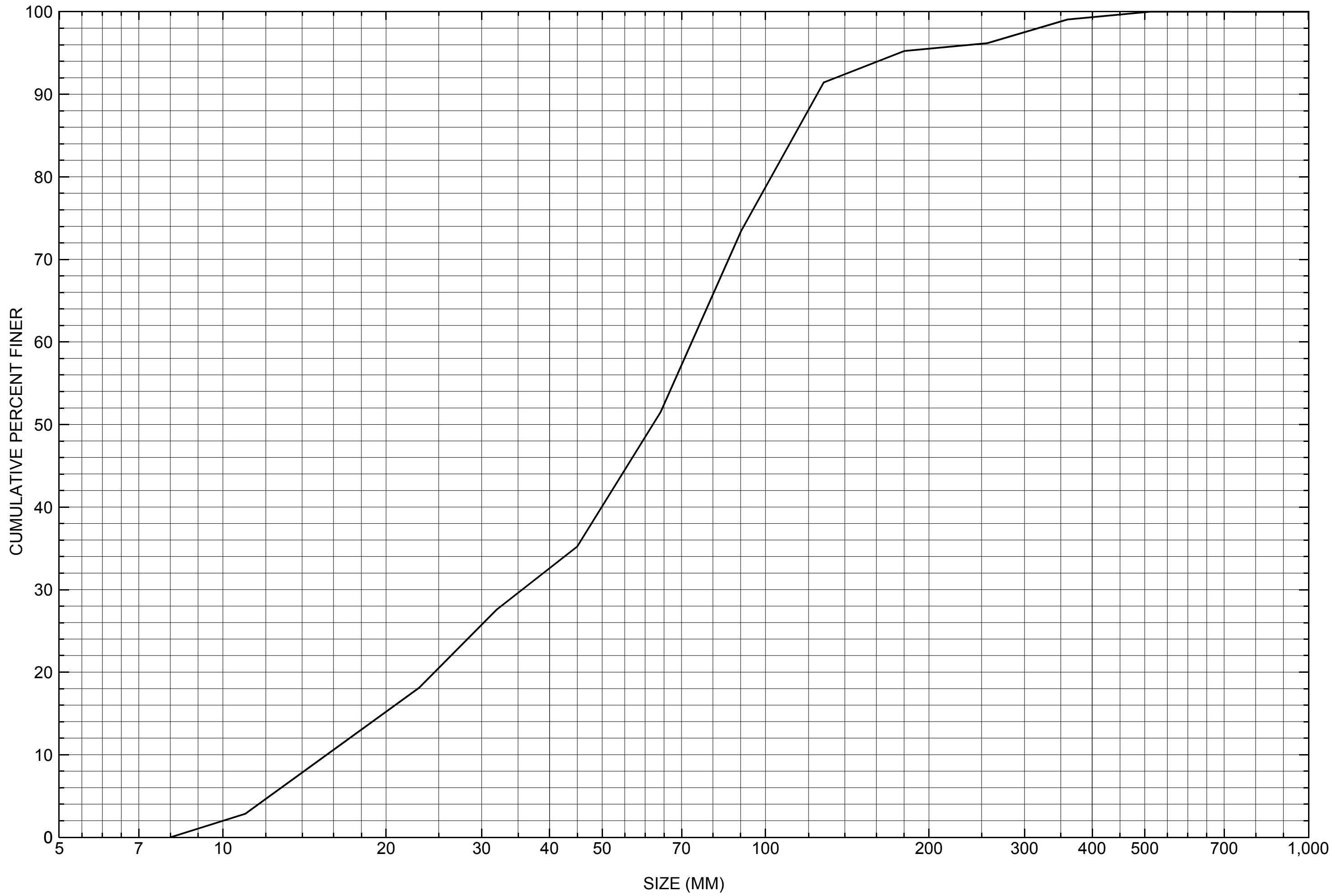

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure CAMBTH00460028, in Cambridge, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number CAMBTH00460028

General Location Descriptive

Data collected by *(First Initial, Full last name)* E. BOEHMLER

Date *(MM/DD/YY)* 03 / 08 / 95

Highway District Number *(I - 2; nn)* 08

County *(FIPS county code; I - 3; nnn)* 015

Town *(FIPS place code; I - 4; nnnnn)* 11500

Mile marker *(I - 11; nnn.nnn)* 000000

Waterway *(I - 6)* SEYMOUR RIVER

Road Name *(I - 7):* -

Route Number TH046

Vicinity *(I - 9)* 0.1 MI TO JCT W CL2 TH1

Topographic Map Mount Mansfield

Hydrologic Unit Code: 02010005

Latitude *(I - 16; nnnn.n)* 44354

Longitude *(i - 17; nnnnn.n)* 72519

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10080200280802

Maintenance responsibility *(I - 21; nn)* 03

Maximum span length *(I - 48; nnnn)* 0033

Year built *(I - 27; YYYY)* 1919

Structure length *(I - 49; nnnnnn)* 000038

Average daily traffic, ADT *(I - 29; nnnnnn)* 000170

Deck Width *(I - 52; nn.n)* 143

Year of ADT *(I - 30; YY)* 92

Channel & Protection *(I - 61; n)* 5

Opening skew to Roadway *(I - 34; nn)* 00

Waterway adequacy *(I - 71; n)* 6

Operational status *(I - 41; X)* A

Underwater Inspection Frequency *(I - 92B; XYY)* N

Structure type *(I - 43; nnn)* 302

Year Reconstructed *(I - 106)* 1975

Approach span structure type *(I - 44; nnn)* 000

Clear span (*nnn.n ft*) 30.8

Number of spans *(I - 45; nnn)* 001

Vertical clearance from streambed (*nnn.n ft*) 9.0

Number of approach spans *(I - 46; nnnn)* 0000

Waterway of full opening (*nnn.n* ft^2) 277.5

Comments:

The structural inspection report of 8/1/94 indicates the structure is a steel stringer type bridge with a concrete deck. The abutments and wingwalls are concrete. The bottom of the right abutment has a "knee wall" in place. The left abutment has a two step concrete footing. The upstream end of the right abutment and the upstream right wingwall are undermined about 15 - 18 inches. There is horizontal penetration of 3 - 20 inches underneath the right abutment. The penetration increases from the roadway centerline to the end of the wingwall. The upstream right wingwall has broken off the abutment at the corner where it meets the abutment wall. **(Continued, page 33)**

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: -

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} - Q_{25} -

Q_{50} - Q_{100} - Q_{500} -

Record flood date *(MM / DD / YY)*: - / - / - Water surface elevation *(ft)*: -

Estimated Discharge *(cfs)*: - Velocity at Q - *(ft/s)*: -

Ice conditions *(Heavy, Moderate, Light)* : Debris *(Heavy, Moderate, Light)*: -

The stage increases to maximum highwater elevation (*Rapidly, Not rapidly*): -

The stream response is (*Flashy, Not flashy*): -

Describe any significant site conditions upstream or downstream that may influence the stream's stage: -

Watershed storage area (*in percent*): -%

The watershed storage area is: - (*1-mainly at the headwaters; 2- uniformly distributed; 3-immediatly upstream oi the site*)

Water Surface Elevation Estimates for Existing Structure:

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*)	-	-	-	-	-
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

Is the roadway overtopped below the Q_{100}? (*Yes, No, Unknown*): U Frequency: -

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft^3/ sec*): -

Are there other structures nearby? (*Yes, No, Unknown*): U *If No or Unknown, type ctrl-n os*

Upstream distance (*miles*): - Town: - Year Built: -

Highway No. : - Structure No. : Structure Type: -

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (*ft^2*): -

Downstream distance (*miles*): - Town: - Year Built: -

Highway No. : - Structure No. : - Structure Type: -

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (ft^2): -

Comments:

A few large boulders are present in the channel and in front of the abutments. There are randomly placed boulders along the upstream and downstream banks. Areas of bank erosion are noted from previous flooding.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **9.94** mi^2 Lake/pond/swamp area **0.0** mi^2

Watershed storage *(ST)* **0.0** %

Bridge site elevation **630** ft Headwater elevation **4,393** ft

Main channel length **4.5** mi

10% channel length elevation **665** ft 85% channel length elevation **2,450** ft

Main channel slope *(S)* **528.89** ft / mi

Watershed Precipitation Data

Average site precipitation - in Average headwater precipitation - in

Maximum 2yr-24hr precipitation event *(I24,2)* - in

Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? N *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: - / -

Project Number - Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB -

Benchmark location description:
NO BENCHMARK INFORMATION

Reference Point (*MSL, Arbitrary, Other*): - Datum (*NAD27, NAD83, Other*): -

Foundation Type: 4 (*1-Spreadfooting; 2-Pile; 3- Gravity; 4-Unknown*)

If 1: Footing Thickness - Footing bottom elevation: -

If 2: Pile Type: - (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: -

If 3: Footing bottom elevation: -

Is boring information available? N *If no, type ctrl-n bi* Number of borings taken: -

Foundation Material Type: 3 (*1-regolith, 2-bedrock, 3-unknown*)

Briefly describe material at foundation bottom elevation or around piles:
NO FOUNDATION MATERIAL INFORMATION

Comments:
NO PLANS.

Cross-sectional Data

Is cross-sectional data available? **Y** *If no, type ctrl-n xs*

Source (*FEMA, VTAOT, Other*)? **VTAOT**

Comments: **This cross section was taken at the upstream face. The low chord elevations are from the survey log done for this report on 7/11/95. The low chord to bed length data is from the sketch attached to a bridge inspection report dated 8/1/94. The sketch was done on 6/1/92.**

Station	0	3.3	12.6	22.6	29.8	30.8	-	-	-	-	-
Feature	LAB					RAB	-	-	-	-	-
Low chord elevation	499.3	499.3	499.3	499.4	499.4	499.4	-	-	-	-	-
Bed elevation	-	491.4	490.4	489.1	490.2	-	-	-	-	-	-
Low chord - bed length	-	7.9	8.9	10.3	9.2	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord - bed length	-	-	-	-	-	-	-	-	-	-	-

Source (*FEMA, VTAOT, Other*)? -

Comments:

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord - bed length	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord - bed length	-	-	-	-	-	-	-	-	-	-	-

APPENDIX E:

LEVEL I DATA FORM

U. S. Geological Survey
Bridge Field Data Collection and Processing Form

Qa/Qc Check by: RB Date: 3/13/96
Computerized by: RB Date: 3/15/96
Reviewd by: MAL Date: 7/22/97

Structure Number CAMBTH00460028

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* M. Ivanoff Date *(MM/DD/YY)* 7 / 11 / 1995
2. Highway District Number 8 Mile marker 0
County Lamoille (015) Town Cambridge (11500)
Waterway *(I - 6)* Seymour River Road Name -
Route Number TH46 Hydrologic Unit Code: 02010005
3. Descriptive comments:

The bridge is located 0.1 miles from the junction with town highway 1.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 RBUS 4 LBDS 4 RBDS 4 Overall 4
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US 2 UB 2 DS 2 *(**1**- pool; **2**- riffle)*
6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*
7. Bridge length 38 *(feet)* Span length 33 *(feet)* Bridge width 14.3 *(feet)*

Road approach to bridge:

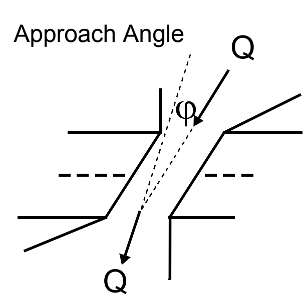
8. LB 1 RB 1 *(**0** even, **1**- lower, **2**- higher)*
9. LB 2 RB 2 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right 4.1:1

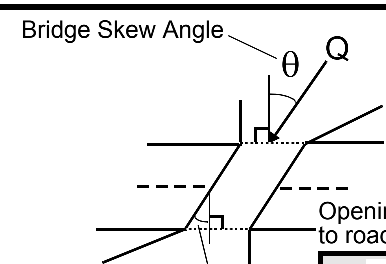
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	1	1	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*
*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: 0 16. Bridge skew: 5





Opening skew to roadway
α= 10.0

17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 15 feet US *(US, UB, DS)* to 0 feet DS
Channel impact zone 2: Exist? N *(Y or N)*
Where? - *(LB, RB)* Severity -
Range? - feet - *(US, UB, DS)* to - feet -

*Impact Severity: **0**- none to very slight; **1**- Slight; **2**- Moderate; **3**- Severe*

18. Bridge Type: **1a**

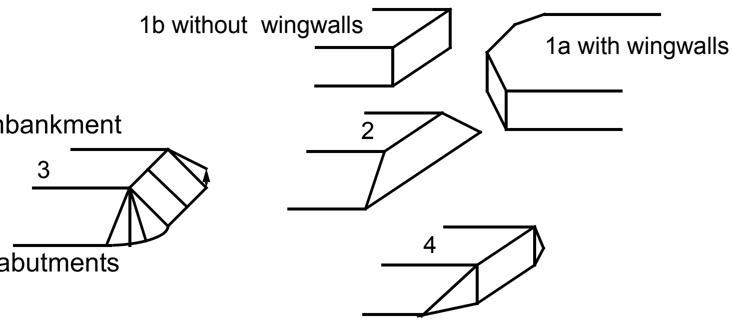
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls parallel to abut. face

3- Spill through abutments

4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.



19. Bridge Deck Comments (surface cover variations, measured bridge and span lengths, bridge type variations, approach overflow width, etc.)

7. The bridge dimensions measured are the same as those available in the VTAOT files.
4. Trees line all the banks with the most vegetated being the left bank US. Beyond the forested banks is pasture within the 2 bridge length range.

C. Upstream Channel Assessment

20. SRD	21. Bank height (BF) LB	21. Bank height (BF) RB	22. Bank angle (BF) LB	22. Bank angle (BF) RB	26. % Veg. cover (BF) LB	26. % Veg. cover (BF) RB	27. Bank material (BF) LB	27. Bank material (BF) RB	28. Bank erosion (BF) LB	28. Bank erosion (BF) RB
36.5	**4.5**			**5.0**	**3**	**3**	**421**	**432**	**0**	**1**

23. Bank width **5.0** 24. Channel width **45.0** 25. Thalweg depth **114.5** 29. Bed Material **435**

30 .Bank protection type: LB **0** RB **0** 31. Bank protection condition: LB **-** RB **-**

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*
*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*
*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

32. Comments (bank material variation, minor inflows, protection extent, etc.):

27. The bank material on the left is comprised of cobbles, sand, and silt. On the right bank the material is comprised of cobble, gravel, and sand.
29. The channel bed material is comprised of cobbles, gravel, and some boulders.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 30 35. Mid-bar width: 20
36. Point bar extent: 80 feet US (US, UB) to 40 feet DS (US, UB, DS) positioned 0 %LB to 50 %RB
37. Material: 43
38. Point or side bar comments (Circle Point or Side; Note additional bars, material variation, status, etc.):
The side bar consists of cobbles and gravel extending through the bridge along the left abutment.

39. Is a cut-bank present? Y (Y or if N type ctrl-n cb) 40. Where? RB (LB or RB)
41. Mid-bank distance: 60 42. Cut bank extent: 30 feet US (US, UB) to 100 feet US (US, UB, DS)
43. Bank damage: 1 (1- eroded and/or creep; 2- slip failure; 3- block failure)
44. Cut bank comments (eg. additional cut banks, protection condition, etc.):
The bank is nearly vertical. However, the trees have remained upright along the bank.

45. Is channel scour present? N (Y or if N type ctrl-n cs) 46. Mid-scour distance: -
47. Scour dimensions: Length - Width - Depth : - Position - %LB to - %RB
48. Scour comments (eg. additional scour areas, local scouring process, etc.):
There is no channel scour present upstream at the site. Settling of the upstream right wingwall suggests scour has been focused in this area during periods of high flow.

49. Are there major confluences? N (Y or if N type ctrl-n mc) 50. How many? -
51. Confluence 1: Distance - 52. Enters on - (LB or RB) 53. Type - (1- perennial; 2- ephemeral)
Confluence 2: Distance - Enters on The (LB or RB) Type re (1- perennial; 2- ephemeral)
54. Confluence comments (eg. confluence name):
are no major confluences present upstream of the site.

D. Under Bridge Channel Assessment

55. Channel restraint (BF)? LB 2 RB (1- natural bank; 2- abutment; 3- artificial levee)

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
46.0		1.0		2	7	7	-

58. Bank width (BF) - 59. Channel width - 60. Thalweg depth 90.0 63. Bed Material -

*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*

*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*

64. Comments (bank material variation, minor inflows, protection extent, etc.):
453
The bed material consists of cobbles, boulders and gravel.

65. **Debris and Ice** Is there debris accumulation? ____ (Y or N) 66. Where? Y____ (1- Upstream; 2- At bridge; 3- Both)

67. Debris Potential 1____ (1- Low; 2- Moderate; 3- High) 68. Capture Efficiency 2____ (1- Low; 2- Moderate; 3- High)

69. Is there evidence of ice build-up? 1___ (Y or N) Ice Blockage Potential N____ (1- Low; 2- Moderate; 3- High)

70. Debris and Ice Comments:

1

There are two fallen trees in the US channel. The banks are well vegetated with trees having diameters of one foot and greater. The bridge opening is 70% of the US channel width.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	2	2	0	2	90.0
RABUT	1	10	90			2	3	30.0

Pushed: LB or RB *Toe Location (Loc.): **0**- even, **1**- set back, **2**- protrudes*
*Scour cond.: **0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**-undermined footing; **4**- piling exposed; **5**- settled; **6**- failed*
Materials: **1**- Concrete; **2**- Stone masonry or drywall; **3**- steel or metal; **4**- wood

79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

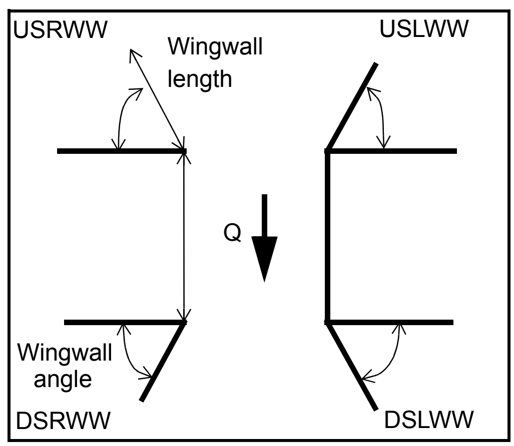
0.2
3.5
1

The left abutment footing consists of two steps extending to the end of the DS wingwall. The right abutment is undermined 0.2 ft with a maximum horizontal penetration of 1 foot at the US face. There is 0.2 ft of localized scour along the right abutment and upstream right wingwall. Finer material must have filled in since the structural inspection of 8/1/94 (refer to historical form).

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						30.0	
USRWW:	Y		1		0	0.5	
DSLWW:	0		0		Y	17.5	
DSRWW:	1		3		0.2	16.5	

*Wingwall materials: **1**- Concrete; **2**- Stone masonry or drywall; **3**- steel or metal; **4**- wood*



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	3.5	2	Y	0	-	-	-	-
Condition	Y	0	1	3.5	-	-	-	-
Extent	1	3.5	2	0	0	0	0	-

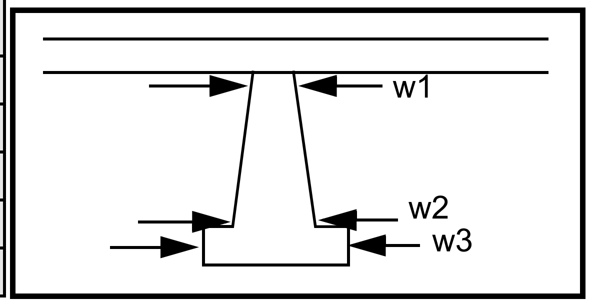
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length; **2**- US end; **3**- DS end; **4**- other*

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
0
-
-
0
-
-

Piers:

84. Are there piers? Th (Y or if N type ctrl-n pr)

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				50.0	18.0	85.0
Pier 2	7.0	8.5	4.5	90.0	80.0	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e US	with a	07/11/	torical	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	right	max-	95).	form	**1**- Solid pier, **2**- column, **3**- bent
88. Material	wing	imu	The	from	**1**- Wood; **2**- concrete; **3**- metal; **4**- stone
89. Shape	wall	m	1.5 ft	a	**1**- Round; **2**- Square; **3**- Pointed
90. Inclined?	is	pen-	pen-	1994	Y- yes; N- no
91. Attack ∠ (BF)	scou	etra-	etra-	struc	
92. Pushed	red	tion	tion	tural	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	and	of	was	inspe	
95. Cross-members	unde	1.5 ft	note	ction	**0**- none; **1**- laterals; **2**- diagonals; **3**- both
96. Scour Condition	rmin	(field	d in	. The	**0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed
97. Scour depth	ed	mea-	the	scou	
98. Exposure depth	0.2 ft	sure	his-	r	

99. Pier comments (eg. undermined penetration, protection and protection extent, unusual scour processes, etc.):

reported in the inspection report of 8/1/94 has been filled in with loose unconsolidated sediments leaving a maximum undermining of 1 ft at the break point between the wingwall and the abutment on the right side. The right upstream wingwall shows signs of settling. There is a vertical crack between the right upstream wingwall and the right abutment. The DS left wingwall consists of a two step footing.

N

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-	-	-	-	-	-	-

Bank width (BF) - Channel width - Thalweg depth - Bed Material -

Bank protection type (Qmax): LB - RB - Bank protection condition: LB - RB -

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*
*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*
*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

Comments (eg. bank material variation, minor inflows, protection extent, etc.):
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

101. Is a drop structure present? - *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

103. Drop: - feet 104. Structure material: - *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

105. Drop structure comments (eg. downstream scour depth):
-
-
-
-
-
-

106. Point/Side bar present? - (Y or N. if N type ctrl-n pb) Mid-bar distance: - Mid-bar width: -

Point bar extent: - feet - (US, UB, DS) to - feet - (US, UB, DS) positioned - %LB to - %RB

Material: -

Point or side bar comments (Circle Point or Side; note additional bars, material variation, status, etc.):

-
-
-
-

Is a cut-bank present? **Th** (Y or if N type ctrl-n cb) Where? **is** (LB or RB) Mid-bank distance: **brid**

Cut bank extent: **ge is** feet **a** (US, UB, DS) to **sin-** feet **gle** (US, UB, DS)

Bank damage: **spa** (**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)

Cut bank comments (eg. additional cut banks, protection condition, etc.):

n without piers.

Is channel scour present? ____ (Y or if N type ctrl-n cs) Mid-scour distance: ____

Scour dimensions: Length ____ Width ____ Depth: ____ Positioned ____ %LB to **2** %RB

Scour comments (eg. additional scour areas, local scouring process, etc.):

3
214
435
1

Are there major confluences? **1** (Y or if N type ctrl-n mc) How many? **435**

Confluence 1: Distance **0** Enters on **0** (LB or RB) Type **-** (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance **-** Enters on **The** (LB or RB) Type **left** (**1**- perennial; **2**- ephemeral)

Confluence comments (eg. confluence name):

bank material consists of sand, silt, and some cobbles. The left bank has finer material than the right bank. The right bank consists of cobbles, gravel, and boulders.

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

1- Constructed
2- Stable
3- Aggraded
4- Degraded
5- Laterally unstable
6- Vertically and laterally unstable

108. Evolution comments *(Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors)*:

N

109. G. Plan View Sketch

point bar (pb)	debris	flow (Q)	stone wall
cut-bank (cb)	rip rap or stone fill	cross-section	other wall
scour hole		ambient channel	

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: CAMBTH00460028 Town: Cambridge
Road Number: TH 46 County: Lamoille
Stream: Seymour River

Initials MAI Date: 07/07/97 Checked: LKS

Analysis of contraction scour, live-bed or clear water?

Critical Velocity of Bed Material (converted to English units)
Vc=11.21*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and others, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	2870	4075	1330
Main Channel Area, ft2	535	600	362
Left overbank area, ft2	675	920	0
Right overbank area, ft2	161	237	46
Top width main channel, ft	114	114	109
Top width L overbank, ft	424	437	0
Top width R overbank, ft	107	160	60
D50 of channel, ft	0.2035	0.2035	0.2035
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	4.7	5.3	3.3
y1, average depth, LOB, ft	1.6	2.1	ERR
y1, average depth, ROB, ft	1.5	1.5	0.8
Total conveyance, approach	86100	123408	21964
Conveyance, main channel	37918	45922	20307
Conveyance, LOB	39150	64352	0
Conveyance, ROB	9032	13134	1657
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1263.9	1516.4	1229.7
Ql, discharge, LOB, cfs	1305.0	2124.9	0.0
Qr, discharge, ROB, cfs	301.1	433.7	100.3
Vm, mean velocity MC, ft/s	2.4	2.5	3.4
Vl, mean velocity, LOB, ft/s	1.9	2.3	ERR
Vr, mean velocity, ROB, ft/s	1.9	1.8	2.2
Vc-m, crit. velocity, MC, ft/s	8.5	8.7	8.1
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	0
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Clear Water Contraction Scour in MAIN CHANNEL

y2 = (Q2^2/(131*Dm^(2/3)*W2^2))^(3/7)   Converted to English Units
ys=y2-y_bridge
(Richardson and others, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	2870	4075	1330
(Q) discharge thru bridge, cfs	1532	1645	1330
Main channel conveyance	19640	21875	8068
Total conveyance	19640	21875	8068
Q2, bridge MC discharge,cfs	1532	1645	1330
Main channel area, ft2	216	233	119
Main channel width (normal), ft	30.0	30.1	29.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	30	30.1	29.8
y_bridge (avg. depth at br.), ft	7.21	7.70	3.99
Dm, median (1.25*D50), ft	0.254375	0.254375	0.254375
y2, depth in contraction,ft	5.33	5.65	4.75
ys, scour depth (y2-ybridge), ft	**-1.89**	**-2.10**	**0.76**

Armoring
Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)
(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	1532	1645	1330
Main channel area (DS), ft2	216.2	231.8	119.2
Main channel width (normal), ft	30.0	30.1	29.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	30.0	30.1	29.8
D90, ft	0.4084	0.4084	0.4084
D95, ft	0.5781	0.5781	0.5781
Dc, critical grain size, ft	0.1755	0.1717	0.5487
Pc, Decimal percent coarser than Dc	0.568	0.578	0.056
Depth to armoring, ft	**0.40**	**0.38**	**27.85**

Abutment Scour

Froehlich’s Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a’/Y1)^0.43*Fr1^0.61+1
(Richardson and others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q

(Qt), total discharge, cfs	2870	4075	1330	2870	4075	1330
a', abut.length blocking flow, ft	488.4	501.4	59.5	126.9	180.2	79.8
Ae, area of blocked flow ft2	567.3	674.2	80	309	396.4	163.9
Qe, discharge blocked abut.,cfs	--	--	126	739.6	927.8	625.1
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.80	2.16	1.58	2.39	2.34	3.81
ya, depth of f/p flow, ft	1.16	1.34	1.34	2.43	2.20	2.05
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	80	80	80	100	100	100
K2	0.98	0.98	0.98	1.01	1.01	1.01
Fr, froude number f/p flow	0.240	0.253	0.239	0.270	0.278	0.469
ys, scour depth, ft	13.14	14.94	6.60	13.76	14.84	13.84

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	488.4	501.4	59.5	126.9	180.2	79.8
y1 (depth f/p flow, ft)	1.16	1.34	1.34	2.43	2.20	2.05
a'/y1	420.47	372.89	44.25	52.12	81.92	38.85
Skew correction (p. 49, fig. 16)	0.97	0.97	0.97	1.02	1.02	1.02
Froude no. f/p flow	0.24	0.25	0.24	0.27	0.28	0.47
Ys w/ corr. factor K1/0.55:						
vertical	5.12	6.03	5.92	11.73	10.70	11.87
vertical w/ ww's	**4.20**	**4.94**	**4.85**	**9.62**	**8.77**	**9.73**
spill-through	2.81	3.31	3.25	6.45	5.88	6.53

Abutment riprap Sizing

Isbash Relationship
D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)
(Richardson and others, 1995, p112, eq. 81,82)

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.46	0.45	0.99	0.46	0.45	0.99
y, depth of flow in bridge, ft	7.21	7.70	4.00	7.21	7.70	4.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	**0.94**	**0.96**	ERR	**0.94**	**0.96**	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	**1.67**	ERR	ERR	**1.67**